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EVALUATION OF RETENTION VALUES OF DIFFERENT TELESCOPIC CROWN ATTACHMENT MATERIALS IN IMPLANT RETAINED OVERDENTURE (AN IN VITRO STUDY)

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ABSTRACT

Statement of problem: A variety of attachment materials were employed to improve stability and retention; nevertheless, some materials show considerable alterations in surface topography upon the application of occlusal stress, which eventually affects denture retention. Recent studies have shown a substantial amount of interest in the usage of metal-free attachment.

Purpose: the aim of this study was examining the impact of various telescopic crown attachment materials on implant-retained mandibular overdentures' retention.

Material and Methods: completely edentulous mandibular epoxy models were constructed; wherein various material combinations have been used for constructing telescopic attachments for two implants placed in the canine area. The traditional standardized method was used to fabricate thirty-three identical mandibular overdentures. Based on the material utilized in constructing the secondary coping, the study groups were divided into three categories: PEEK/PEEK, PEEK/ZrO_2, and PEEK/CoCr. For each research group, primary PEEK copings were created. On a prefabricated abutment, primary copings were cemented in place. In the intended insertion path, secondary copings were positioned over the primary copings and then lifted up into the overdentures' intaglio surface. In order to assess each group's retention value, a vertical load of 100 N was adjusted in the universal testing machine. Insertion-removal cycles were applied repeatedly using a cyclic loading machine to simulate nearly 10 years of clinical use.

Results: The mean retention values for PEEK-PEEK, PEEK-ZrO_2, and PEEK-CoCr groups varied from 2.19 to 1.16 N, 5.78 to 2.51 N, and 1.15 to 0.31 N, respectively. The retention varied statistically significantly throughout the study groups. PEEK/PEEK recorded the highest retention value, followed by PEEK/ZrO_2 and PEEK/CoCr, respectively.

Conclusions: The telescopic crown materials have an impact on both the retention forces, even in cases when the identical crown design is selected. Within the limitations of this investigation, the combination of PEEK-PEEK, followed by PEEK-ZrO_2, demonstrated superior retention results.

CLINICAL IMPLICATION: Since PEEK-PEEK combination offers superior retention, it might be the preferred method for fabricating telescopic attachments in implant-retained overdentures. It improves long-term patient satisfaction and extends the prosthesis' shelf life by reducing surface wear, which lessens its impact on retention. These benefits are especially beneficial for elderly patients since they lessen the need for frequent attachment replacement and repair.

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INTRODUCTION

In the rehabilitation of edentulous mandibles, telescopic attachments have been used to secure overdentures since 1989. Two implants with strong telescoping attachments implanted in the canine region for overdenture retention in the severely atrophied edentulous mandible proved to be a successful long-term treatment alternative[1].

Cobalt-chromium has been used to build telescopic crown attachments in the past. Nonetheless, peri-implantitis has been linked in numerous studies to the existence of corrosion products surrounding the implant. Other metals, such as titanium and base metal alloys, can be used as substitute materials for double crowns. All the same, non-metallic alternatives must be used because of documented sensitivity to some of these metals. A small number of people reported sensitivity to nickel and, to a lesser extent, to cobalt. [(2)]

In addition to offering sufficient stability and retention, telescoping crown attachments improve phonation and mastication. The friction between the outer and inner crown axial walls, heights, and crown tapers are some of the factors that affect the manner in which double-crown-retained prostheses retain in their position [(3)]. However, material wear over time may cause retention to diminish [(4)]. Significant progress has been achieved concerning dental materials, and new trends are evolving. But every novel dental material developed throughout time has been compared with existing well-known materials, such metal alloys [(5)].

The primary crown is usually made of highly wear-resistant materials, whilst the secondary crown is made of more flexible ones[(6)]. Alternatives to double-crown-retained overdentures that are more affordable, aesthetically pleasing, biocompatible, and provide similar precision and long-term retention are being researched by manufacturers and medical professionals.

It was initially reported in 2000 that ceramic materials were utilized in the manufacturing of telescopic attachments [(7)]. In comparison to precious alloys, zirconia is non-corrosive, has a color similar to teeth, and has a superior mechanical strength, wear resistance, and biocompatibility. Accordingly, the materials chosen for double-crown systems greatly affect how long they last [(8)].

The principal thermoplastic high-performance polymer group that is improved to create PEEK is poly-ether-aryl-ketone (PEEK). Both PEEK and ZrO_2 exhibit great biocompatibility in a range of dental applications, such as fixed dental prostheses (FDP), dental implants, and temporary abutments[(9)]. PEEK has been identified as a suitable material for the double-crown design[(10)]. Non-metallic telescopic crowns were created by combining these two biocompatible materials (PEEK and ZrO_2).

As a result, the objective of this in vitro investigation was to determine the effect of different material combinations in the design of telescopic attachments for retaining a potential overdenture. The null hypothesis was that using different material combinations had no effect on retention or wear resistance while building a telescoping attachment for an implant-retained overdenture.

MATERIAL AND METHODS

The main objective of the research was to ascertain how well various material combinations would work for retention when building a telescopic attachment to support an overdenture that is implant retained.

Using R software, the sample was computed at the 0.05 significance level, with a pooled standard deviation of 6.85. Thirty-three mandibular overdenture samples in total were used, and they were split into three groups, with eleven models per group.

All the primary copings were constructed out of PEEK [(11)]. However, the study groups were divided based on the materials utilized to create the secondary crowns. Group I included PEEK secondary coping, Group II of ZrO_2 secondary coping, and Group III of CoCr secondary coping.

1- Fabrication of mandibular replica

To avoid air bubbles in the finished model, a clear epoxy resin was quickly poured into a premade mold in compliance with the manufacturer's instructions. The mold containing the epoxy resin model was taken out and utilized to create a mandibular edentulous replica.

2- Denture construction

A trial denture base with an occlusion rim attached was manufactured using visible-light-cure acrylic resin (VLC). The occlusal plane height of the anatomic (30°) teeth was carefully adjusted after implantation to ensure that they did not extend over half of the retromolar pad area. Following established, standardized procedures, thirty-three identical full mandibular overdentures were created.

3- Surgical Guide Fabrication

In order to modify the overdenture for use as a radiographic surgical template, gutta-percha cones were attached to both sides of the mandibular canine area. Using CBCT, a virtual radiography scan of the model was obtained. The Dicom series was then analysed using OnDemand3D software. A CAD/CAM system was used to create the surgical guide, which was then manufactured using a Formlab 3D printer with two metal holes positioned over the locations of the intended implants (Fig. 1).

4- Placement of implants in the epoxy-resin models

Implants were positioned bilaterally at the designated implant locations using serial drills, drilling down to the precise depth stated on the drills, up to a maximum depth of 10 mm. The implant site was flared using a countersink drill to facilitate the simple insertion of two implants with a diameter of 3.3 mm and a length of 10 mm. This resulted in the achievement of a primary stability of 35 Ncm. In order to prepare for the next adjustment, implant abutments were then screwed to the implants using a torque wrench until they reached a 20 Ncm torque.

Fig. (1) Fabrication of surgical guide.

5- Implant's abutments preparation and attachment fabrication

Prefabricated abutments with a 6° axial taper and 1.2 mm shoulder were lowered to a 4 mm axial height. An InaEos X5 extraoral scanner (Sirona, Germany) was used to scan the prepared abutments next. First, a common path of placement was taken into consideration while designing the cylindrical primary copings. Next, the primary copings were milled from PEEK by (Formlabs, Somerville, MA, USA).

6- Surface treatment of the PEEK primary coping and the implant abutments

To improve bonding strength and create a micro-rough surface, 50 µm grain size particles of aluminum oxide were sandblasted for 15 seconds at 0.2 MPa (3 bar pressure, distance 1 cm, 15 repetitions) on both the exterior and inner surfaces of the PEEK main copings and implant abutments[12]. To generate a micro-roughened surface and facilitate the adherence of the cement material, 98% sulfuric acid was applied to the inner surface of PEEK for a duration of 30 seconds [13, 14].

7- Cementation of the primary coping

Dual cure resin cement was applied using Hancem resin cement, following the manufacturer's recommendations, to bond the PEEK primary coping over the implant abutments. (Fig. 2, 3 & 4).

8- Fabrication of secondary copings

In order to replicate the crown wall conversion of the primary coping, Zirconia coping (ZrO_2) was planned and manufactured for the secondary coping using the same programme and milling equipment. The Cobalt-Chromium copings (CoCr) were first machined with CAD/CAM laser technology, following the same parameters as the other study groups [15].

9- Pick-up procedure for final overdenture fabrication

The secondary telescopic crowns were positioned on top of the primary crowns on the transparent acrylic resin model. The denture's fitting surface had venting holes punched through the lingual flanges. Using self-cured acrylic resin, secondary crowns were positioned over the primary crowns in the correct insertion route and then lifted up to the overdenture's intaglio surface.

10- Denture preparation for testing

In order to engage the denture and apply the pull-off test, a metallic cobalt-chrome bar attachment was designed. The grasping hook was placed in the middle of the bar to facilitate the tensile stress application (Fig. 5). The acrylic resin that self-cured was used to hold the bar attachment in place. The models were placed in a universal testing machine in order to evaluate the retention force [16].

Retention test[17, 18]

A 100 N applied load was supplied during the tensile load test, which was carried out at a pace

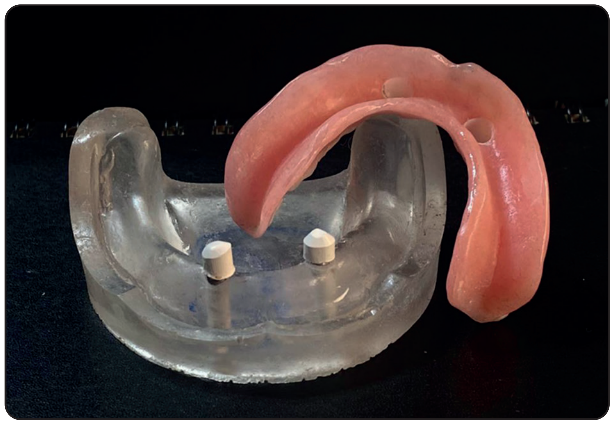

Fig. (2) ZrO2 secondary coping.

Fig. (3) CoCr secondary coping.

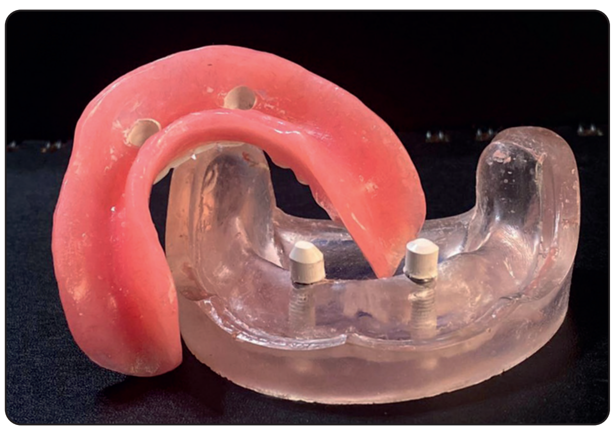

Fig. (4) PEEK secondary coping.

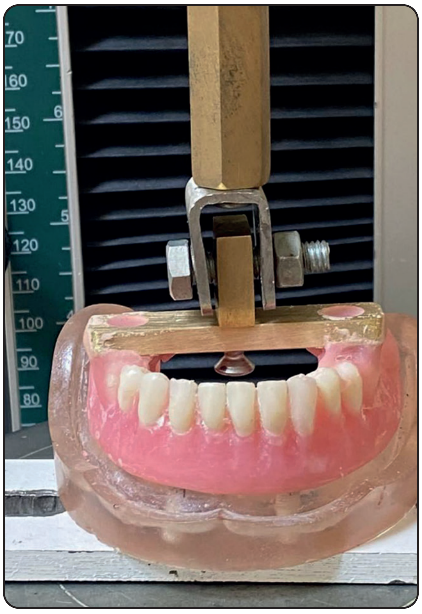

Fig. (5) A metallic bar attachment constructed from cobalt-chrome with a gripping hook positioned in the middle was designed for grasping the denture and transferring the tensile force.

of 5 mm/min until the denture separated from the model. A vertical tensile force was applied to the dentures using the universal testing machine until the attachments separated from the abutments.

In order to simulate about ten years of intraoral function, repeated insertion removal cycles at 1.000, 5.000, and 10.000 cycles were applied using a cyclic loading machine set to run at 30 mp. A universal testing machine was used to re-evaluate the models following each cycle in order to track the gradual decline in retention values [16].

I. Results of retention force evaluation:

At multiple follow-up intervals, including before the application of repeated insertion removal cycles (initial retention), after 1.000 cycles, after 5.000 cycles, and after 10.000 cycles (final retention), the retention force (in Newtons) for each group was measured.

Table (1) shows that the mean initial retention of the study groups. Initial retention values revealed a substantial statistical difference between the groups under research; PEEK-PEEK had the best score of all the groups under study, followed by PEEK-ZrO_2 and PEEK-CoCr, respectively. This difference was also evident following the application of 1.000, 5.000, and 10.000 insertion removal cycles.

Table (2) shows that the mean retention after the application of 1.000 cycles.

Table (3) shows that the mean retention value at 5.000 cycles.

Table (4) shows that the mean retention at 10.000 cycles.

TABLE (1) Comparison of initial retention values between the study groups at baseline.

	PEEK-PEEK		**PEEK-ZrO_2**		**PEEK-CoCr**		**Sig.**
	Mean (N)	**SD.**	**Mean (N)**	**SD.**	**Mean (N)**	**SD.**	
Initial retention	5.78[a]	0.66	2.19[a]	0.68	1.15[a]	0.29	p^a <.001*
Between groups Sig.	*pGroup1-Group2=<.001**						
	*pGroup1-Group3=<.001**						
	*pGroup2-Group3=<.001**						

TABLE (2) Comparison of retention values at 1.000 cycles between study groups.

	PEEK/ PEEK		PEEK/ZrO_2		PEEK/CoCr		Sig.
	Mean (N)	SD.	Mean (N)	SD.	Mean (N)	SD.	
Retention at 1000 cycles	2.70 ^{b}	0.41	1.35 ^{b}	0.29	0.39 ^{b}	0.21	p^b<.001*
Between groups Sig.	pGroup1-Group2=<.001*						
	pGroup1-Group3=<.001*						
	pGroup2-Group3=<.001*						

TABLE (3) Comparison of retention values at 5.000 cycles between study groups.

	PEEK/ PEEK		PEEK/ZrO_2		PEEK/CoCr		Sig.
	Mean (N)	SD.	Mean (N)	SD.	Mean (N)	SD.	
Retention at 5000 cycles	2.60 ^{c}	0.40	1.27^c	0.28	0.36^c	0.19	p^c <.001*
Between groups Sig.	pGroup1-Group2 = <.001*						
	pGroup1-Group3 = <.001*						
	pGroup2-Group3 = <.001*						

TABLE (4) Comparison of retention values at 10.000 cycles between study groups.

	PEEK/ PEEK		PEEK/ZrO_2		PEEK/ CoCr		Sig.
	Mean (N)	SD.	Mean (N)	SD.	Mean (N)	SD.	
Retention at 10000 cycles	2.51 ^{d}	0.40	1.16 ^{d}	0.28	0.31 ^{d}	0.17	p^c <.001*
Between groups Sig.	pGroup1-Group2=<.001*						
	pGroup1-Group3=<.001*						
	pGroup2-Group3=<.001*						

DISCUSSION

The results of this investigation showed that the preservation of the overdenture is impacted by the various material combinations employed in the fabrication of the main and secondary crowns of the telescopic attachment. Consequently, the null hypothesis was rejected.

The physical characteristics of the materials, their cohesiveness together, and their capacity to absorb occlusal pressures all contribute to higher retention values, which explains these results. Additionally, some materials' lower surface roughness lowers friction between contacting surfaces during removal and insertion cycles, which may be the reason for less wear.

As per the findings of this investigation, the PEEK-PEEK group was able to sustain a consistent level of retention after 10,000 cycles, which replicated almost a decade of intra-oral overdenture performance. These results are consistent with a ***Wagner et al***. investigation [19] in which PEEK-made telescopic crowns demonstrated steady retention load values.

When compared to other study groups, the PEEK-PEEK combination performed better in the current investigation. Similar results were found in ***Tribst et al.*** [20] investigation, which revealed low stress concentration on PEEK material. This could be attributed to the material's high strength and low elastic modulus.

This was consistent with the findings of ***Micovic et al.*** [21], who examined the retention load of several material-made telescopic crowns. PEEK crowns demonstrated a high retention load value, however ZrO2 and CoCr secondary crowns demonstrated a consistent and noteworthy drop in retention pressures when evaluated on both types of primary crowns.

In contrast with the findings of an in vitro investigation reported by ***Schubert et al.*** [8], which showed that the ZrO_2-PEEK group had the highest mean starting values. After ***Schubert et al.*** [8] determined that more flexible materials should be used for secondary crown construction rather than wear-resistant materials like ZrO_2 for primary crown construction.

Moreover, the authors reported that during the investigation, the long-term friction force for PEEK-PEEK remained unchanged. These results are consistent with the research conducted by ***Tribst et al.*** [20] concluded that the most promising combination for telescopic crown retained overdentures was PEEK–PEEK crowns.

However, a study by ***Emera et al. (2019)*** disapproved of our findings, indicating that PEEK-ZrO_2 crowns performed better in terms of the implants' ability to preserve mandibular full overdentures. The low wear and abrasion resistance of zirconia crowns could be one reason for this.

CONCLUSION

Even when the identical crown design is used, the materials utilized for telescoping crowns have an impact on retention forces; PEEK-PEEK and PEEK-ZrO_2 combinations produced the best retention values. Metal particles were observed to be deposited on the primary coping surface in PEEK-CoCr copings.

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